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AMERICAN HOMOTAXIAL EQUIVALENTS OF THE  
ORIGINAL PERMIAN <sup>1</sup>

IN this country the Permian question has long remained open. Its various phases are essentially the same today as they were forty years ago, when Permian faunas were first thought to be identified in the rocks of Kansas. For nearly a quarter of a century comparatively little information was added. Recently, however, active interest in the subject has been renewed, and new data have been acquired. With this revival of interest bob up also all the old questions. Concerning these there is as much difference of opinion as ever. Besides, new problems are presented.

In all of the discussions concerning the American Permian which have taken place in past years certain important facies of the theme have appeared to be wholly overlooked. In the newer considerations there is also a manifest tendency to pass over these very essential qualities. It seems pertinent, therefore, to consider briefly some of these phases of the subject. The following notes and comments are to be regarded as suggestive along the line indicated. No formal attempt is made to correlate in detail the terranes mentioned.

<sup>1</sup> Read before the Geological Society of America, December 28, 1898.  
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## AMERICAN ROCKS ORIGINALLY REFERRED TO THE PERMIAN

*Historical note.*—Regarding the Permian in this country, three questions are prominently presented: (1) Should the Permian be recognized in America? (2) If so, what is the taxonomic rank of the succession of beds referred to it? (3) What are the upper and lower limits of the terrane so called? These questions are perfectly distinct, though they are usually considered together.

The introduction of Murchison's term Permian into the literature of American geology was due to Meek and Swallow, in 1858. The year previous, Hawn had collected, in central Kansas, the fossils identified by them as Permian forms. The beds from which these organic remains were taken form a part of an extensive sequence that extends in a broad belt from eastern Nebraska, through Kansas and Oklahoma, into central Texas. To this province the present notes refer.

After the first announcement of the discovery of supposed Permian fossils in this region, the subject was frequently discussed during a period of more than a dozen years. Meek, Swallow, Hawn, Shumard, Hayden, Newberry, Marcou, and Geinitz, made the principal contributions. Later White and Broadhead took up the subject to some extent. Recently Cragin and Prosser, in Kansas, and Cummins, in Texas, added much to our knowledge of the rocks in question.

The wholly disconnected character of the work of these authors is unfortunate. Except in a general way, it has been, heretofore, impossible to make any satisfactory comparisons between the different parts of the province. Only recently has any relationship been established between the results obtained by the various explorers of this region. Prosser has been chiefly instrumental in giving us something tangible to work upon. In connection with his own investigations, he has made a special effort to bring some of the earlier acquired results into close correspondence. The upper part of so-called Permian in Kansas still remains rather uncertain as to its natural subdivisions, and its relations to other sections. The lower part and the underlying

"Upper Coal Measures" along the Missouri River, which may be regarded as the standard section, have been lately carefully correlated.

The recent work has been sufficient to give us a good idea of the general character of the deposits regarded as Permian, the stratigraphical succession in the different parts of the province, the range of many species of fossils, and an outline of the main subdivisions that it will be useful to recognize.

*Character of deposits.*—The beds of the Continental Interior basin that have been considered as Permian, or Permo-Carboniferous and Permian, consist of two heavy shales, separated by thick limestones. The total thickness in Kansas is probably about 2000 feet; in Texas perhaps double this figure.

The lower beds are almost wholly made up of argillaceous and sandy shales, yellow, brown, green, and blue in color, and brown shaly sandstones. Occasionally occur thin, rather impure limestone bands, that carry abundant fossils. Near the bottom of the formation are some workable coals, associated with which is a characteristic flora.

The median number is composed largely of gray and buff limestones, often in thick layers, shaly limestones, and calcareous shales. The heavy limestones contain more or less chert in nodules and discontinuous bands. Abundant fossils are represented.

The upper part consists principally of gray, variegated, and red shales, and shaly limestones. Gypsum and salt deposits occur abundantly. Fossils occur only very sparingly.

In the main, the deposits indicate shallow waters, in strong contrast to the thalassic conditions that prevailed previously in the same regions. The sediments were laid down largely in closed basins, which finally become altogether dry.

*General geological section.*—In Kansas the general succession, as made out by Prosser and Cragin, is about as follows :

## SECTION OF UPPER CARBONIFEROUS TERRANES OF KANSAS

Terrane	Thickness	Character
Kiger shales.....	210	Shales and sandstones, red chiefly (Upper "Red Beds"), with some gypsum, and thin dolomitic layers.
Cave Creek gypsum.....	40	Gypsum, massive, with some red shale.
Salt Fork shales.....	1000	Shales, and shaly sandstones, red (Lower "Red Beds"), with rock-salt and gypsum.
Wellington shales.....	350	Shales (lower salt measures), variously colored, gray predominating below, and gypsum.
Marion shaly limestones...	150	Limestones chiefly, gray and buff, thinly bedded.
Chase limestones.. ..	250	Limestones, heavily bedded, much chert, and calcareous shales.
Neosho shales.....	140	Shales, yellow, green, and brown, with few thin limestone bands.
Cottonwood limestone....	10	Limestone, fusuline, buff.
Wabaunsee shales.....	550	Shales, sandy, argillaceous, with a few thin coal seams.

*Relations of Texas section.*—In northern and central Texas the beds called Permian are well developed. Cummins separates the succession into three parts, which he terms the Wichita, the Clear Fork, and the Double Mountain, each being regarded about 2000 feet thick. According to this author, the section of the Paleozoic above the lower Carboniferous is:

## CARBONIFEROUS TERRANES OF NORTHERN TEXAS

Terrane	Thickness	Character
Double Mountain.....	2075	Shales, red, sandy, often saline, with some earthy limestones, and much gypsum.
Clear Fork.....	1975	Limestones, and calcareous reddish shales, some sandstone.
Wichita.....	1800	Shales and sandstones, and some conglomerates.
Albany .....	Wanting.	Limestones.
Cisco .....	840	Shales, with coal beds.
Canyon .....	930	Limestones, with shales.
Strawn.....	950	Shales and shaly sandstones.
Millsap.....	1000	Shales, with coal beds, and shaly sandstones.
Lower Carboniferous.....		

Just what parallelism should be instituted between the Texas and Kansas beds is not yet quite clear. The apparent enormous

development of the beds in question in Texas as compared with those north of the Wichita range, and the meager information, of an exact kind, regarding the former, make any attempt at correlation little short of guesswork. However, White's fossils, collected in the upper Wichita and lower Clear Fork, indicate an horizon near the Plattsmouth beds of Nebraska. The Albany seems to be very nearly equivalent to the Missourian series below the horizon just mentioned. The Double Mountain beds are, in a broad way, manifestly approximately equivalent to Cragin's Cimarron series. This leaves a considerable part of the Clear Fork beds representing the Chase and Marion of Kansas. There are in Texas indications of an unconformity at the base of the Clear Fork. Should this prove true, as now seems probable, it amply accounts for a number of hitherto inexplicable phenomena connected with the Kansas rocks, above the main limestones of the Missourian.

*Organic remains.*—It is unfortunate that, with all the advantages that the various workers in the so-called Permian have had, the information regarding the faunas is so meager. Fossils are abundant, at least up to the middle of Prosser's Marion. Such as have been recorded present some interesting phases.

It cannot be gathered from the discussions concerning the fossils found in the Upper Paleozoic west of the Missouri River, in Kansas and Nebraska, just what should be considered the typical "Permian" fauna. The appearance of abundant lamelli-branches and the disappearance of brachiopods seem, as noted elsewhere, to be the most notable features to which attention has been called. Geinitz, considering the fossils found in the Nebraska beds, which he referred to the Dyas, had before him both types. These strata are now known to be partly immediately below the Wabaunsee and partly the very base of the latter. Geinitz did not misinterpret their position so badly as Meek and others would have us believe. His comparisons were made with European standards, and if such comparisons can have any value at all they indicate a degree of acumen on the part of the German paleontologist that few Americans credit him.

Meek's exhaustive criticism of Geinitz's work on the Nebraska faunas, and his other papers on the same subject, appear to be largely misinterpreted by later writers. So far as I am able to find out, Meek's efforts were not directed so much against the view of the Permian age of the Plattsmouth beds as they were to emphasize the fact that the faunas followed one another uninterruptedly from the "Upper Coal Measures" up to the "Red Beds." He was unable to see how a "new and distinct system" could be represented in such a perfectly continuous sequence.

The case of Meek and Swallow is different. It was, after all, a mere quibbling about unimportant details. With all their bitter controversies, their views were not very far removed from each other. Their subdivisions were practically the same. Only different names were employed. Swallow regarded the Paleozoic section above (approximately) the Cottonwood limestone, as divided into Lower Permian and Upper Permian. Meek, selecting dividing horizons slightly different, called the one Permo-Carboniferous and the other Permian. Both agreed in the upper member being Permian. Regarding the lower member, Swallow thought Permian fossils predominated; Meek considered species of the Upper Coal Measures more abundant. Neither seems to have presented any decisive proofs one way or the other.

Prosser's late classification of the central Kansas rocks claims to be based upon the faunas. The subdivisions are properly given special geographic names, but the division lines are very nearly the same as those selected by the earlier writers. The faunal evidence, as Prosser has set it forth in detail, appears to oppose, rather than to support, the conclusions he has drawn.

*Range of fossils.*—In all the faunal considerations that relate to the Upper Paleozoic of Kansas, the rapid disappearance of the brachiopod fauna "characteristic of the Upper Coal Measures," and its replacement by a "Permian" lamellibranch fauna, is pointed out as very significant. Such a comparison is hardly justifiable. The two cannot be thus contrasted any more than a fauna with a flora. They have no common points of relationship. The appearance of the latter in place of the former indicates a

change in physical conditions, but in this case nothing more. Similar and even more marked changes occur at a hundred different horizons in the Carboniferous lower down. When shallow waters prevailed, lamellibranch and gasteropod faunas occupied the areas. When pelagic conditions occurred, the occupants of the district were chiefly brachiopods. The latter moved in as the former moved out. Comparisons of faunas of different classes avail little; they must be of the same class if tangible results are to be expected.

In drawing conclusions regarding the fossils of the beds that have been referred to the Permian and the Permo-Carboniferous, the utmost caution is imperative. The terranes have been only very imperfectly and very unequally explored. Comparisons of faunas have been largely between zoölogical groups of different classes. Many of the beds in the general vertical section are understood only in a vague way. There are long intervals about which nothing either stratigraphically or faunally is known. With a few isolated exceptions, organic remains have yet been found only in the lower half of the succession. Fossiliferous beds reach, according to our present knowledge, only up to the middle of the Marion. In Texas the "Permian" fossils described by White and Cope were from the Wichita and Lower Clear Fork beds.

Taking the fossils, the horizons of which are definitely known, and as chiefly determined by Prosser, fifty-two species are recorded from the Wabaunsee. Of these only two new ones occur in the Cottonwood. In the Neosho following, one third of the twenty-one species noted are not reported from the lower beds; they are lamellibranchs. In the Chase eleven of the thirty-three species appear for the first time. The Marion contains fewer species, but they are forms occurring at lower horizons. The principal brachiopods run through the whole sequence.

#### THE ORIGINAL PERMIAN

*Historical statement.*—The Upper Paleozoic rocks occurring along the western flanks of the Urals, in eastern Russia, in



Europe, were thought by Murchison to constitute a distinct system, equal in rank to Carboniferous and Silurian. He named it, in 1841, after the ancient kingdom of Perm. Since that time much has been learned regarding this great terrane in the Russian provinces. Numerous comparisons have also been made with supposed equivalents in other parts of the world.

A notable fact regarding the Russian Paleozoic rocks above the Devonian is that in nearly every respect they are very similar to those forming the same part of the general geological section developed in the Mississippi Valley. The original Permian presents almost the identical features that do the beds so called in Kansas and Texas. And, strangely enough, the identical questions that have arisen in this country are bones of contention among Russian geologists.

Those who took part in the long excursions in eastern, central, and southern Russia before and after the sessions of the Seventh International Congress of Geologists, held in St. Petersburg in August 1897, had ample opportunity to study the original Permian under the most favorable circumstances. Under the personal guidance of Messrs. Karpinsky, Tschernyschew, Pavlov, Amalilsky, and Nikitin, especially, the typical and critical sections were examined and the fossils of the various horizons collected. With the aid of the official maps, such literature of the region as was at hand, and the explanations offered by the geologists mentioned, who with others had worked in the district and were well acquainted with the details, an unusually good idea of the Russian Permian was obtained.

To those from America, who were especially interested in the Carboniferous and Permian, this experience furnished much desired information. The similarity of the deposits, of their faunas, and of the questions concerning them, in the Russia and Mississippi provinces, seems to make some comparison of their features worthy of formulation. The bearing that a direct knowledge of the former has upon the latter will certainly tend to make our own problems easier of solution.

*Distributions of the terranes.*—The Carboniferous and Permian

rocks of Russia extend from the Arctic Ocean to the Black Sea—a distance of 1500 miles—and from the Urals westward a distance of 1200 miles. In the central and southern parts of the area is a thin covering of Cretaceous and Tertiary deposits. This vast basin, with its nearly horizontal strata, is comparable to our own Carboniferous basin of the Mississippi valley. In the latter region the lower portion of the sequence—or Coal Measures—predominates. In Russia the upper part, or Permian, forms the surface in most of the region.

Around the margins of the great basin, especially on the west and east sides, the Carboniferous is well developed. The lower Carboniferous, made up of limestones, is well displayed, lying immediately upon the Devonian. Relatively speaking, the Coal Measures are not very well represented, though the southern coal field, or Donetz basin, covers 1200 to 1500 square miles, and the central field, or Toula basin, has about the same area. On the flanks of the Urals some coal is also found.

The most typical sections of the Permian are in the Kama River Valley. The great Volga Valley, above Samara, is occupied chiefly by the so-called Permo-Trias.

*Nature of the rocks.*—The beds that are called Permo-Carboniferous, Permian, and Permo-Trias, which occur in the Kama River Valley present the most typical phases of Murchison's "system." The whole succession is tripartite. Shales, sandstones, and marls are separated medially by heavy dolomitic limestones.

The lower member consists of argillaceous and sandy shales, shaly sandstones, marls, and some impure limestones. Sometimes conglomerates are present. Abundant fossils are represented. Upwards of 300 species have been listed. A distinctive flora is also present.

The median terrane is made up chiefly of massive dolomitic limestones, separated by calcareous shales. It forms a striking contrast to the beds above and below.

The upper member is formed of variegated argillaceous and sandy shales, brown shaly sandstones, some of which are copper-bearing, marls, and occasionally thin limestone bands. Gypsum

is also frequently disseminated. The inferior portion is fossiliferous. Above this part come other shales, marls, and sandstones, almost destitute of fossils. They are thought by some authors to be Triassic.

The passage from the prominent marine phase of the Uralian Carboniferous to the subsequent shallow-water conditions is remarkable. The same closed basin depositions are as noteworthy as in the case of the American.

*General section.*—The Paleozoic beds above the strictly marine Carboniferous, as made out in the Ural region, are grouped by the Russian geologists in the following way:

UPPERMOST PALEOZOIC TERRANES OF EASTERN RUSSIA

Terrane	Symbol	Character
Tartaran	PT or P <sub>3</sub>	Shales and marls, "Red Beds," very few fossils.
Zechstein (in part)	P <sub>3</sub>	Marls, limestones, and sandstones.
————	P <sub>b</sub>	Sandstones, shales, and marls with nodular limestones).
————	CP <sub>c</sub>	Dolomitic limestones (base of Murchison's Permian).
Artinsk	CP <sub>g</sub>	Shales, shaly sandstones. This and next terrane above are called Permo-Carboniferous.
————	C <sub>3</sub>	Limestones.

*Faunas represented.*—The so-called true Carboniferous of the Urals is made up almost entirely of limestones. The highest member symbolized by the Russian geologists, C<sub>3</sub>, contains a prolific fauna, which, while chiefly brachiopodous, has also a good representation of corals, some lamellibranchs, and fusulinæ.

Following, are the transition faunas to the Permian, according to the Russians, and by them called Permo-Carboniferous. The two members which comprise it contain, as pointed out by Tschernyschew, very nearly the same organic forms, consisting largely of lamellibranchs, gasteropods, and brachiopods. The lower terrane, termed the Artinsk, is notable for the ammonites that are found in it, which the author just mentioned compares with those lately found in the Texas Permian. The upper

terrane (CP<sub>c</sub>), made up of dolomitic limestones largely, is the basal number of Murchison's original Permian.

The bottom terranes of the Permian, as now recognized by the members of the Russian geological survey, present a great paucity of fossils. The forms are chiefly lamellibranchs, yet in some layers are fragmentary plants.

The median part of the Permian carries what has been regarded as the typical German Zechstein fauna.

About the upper terrane there is much dispute as to age. The Russian geologists are about equally divided. Amalitzky considers it Permian. By others it is regarded as Triassic. Fossils occur rarely. Those found are chiefly lamellibranchs.

*Base of Murchison's Permian.*—As already noted incidentally, the lower limit of the original Permian, as established by Murchison in 1841, is the bottom of the dolomitic limestone immediately overlying what is called the Artinsk terrane. The geologists who have worked in the region place this line in the middle of the Permo-Carboniferous. The succession of strata and the sequence of faunas are continuous from the Carboniferous to the Permian. The transition is so gradual that it appears impossible to locate a satisfactory line of division between the two. The conditions are identical with those that we have encountered in this country, and, following our example, the Russians have adopted our term—Permo-Carboniferous.

While the adoption of such a course emphasizes the transitional character of the faunal sequence, it complicates, rather than simplifies, matters. Two important divisional phases are recognized, both of which are as vague and unnatural as the one that this plan aims to obviate. On all other than faunal grounds, Murchison's lower limiting horizon of the Permian is the most satisfactory and perhaps also the most natural.

#### COMPARISON OF THE RUSSIA AND MISSISSIPPI VALLEY CARBONIFEROUS

*Stratigraphic parallelism.*—In Russia and in the Mississippi valley the general geological sections of the upper Paleozoic

are remarkably alike. The basins occupied by these rocks are very nearly of the same size. As already stated in the first-mentioned area, the Permian very greatly predominates as the surface rock. In the last-named, the coal measures. The Carboniferous of Russia presents two very distinct aspects—a thalassic facies, occurring on the western flanks of the Urals, and made up of limestones chiefly; and a shallow water or littoral phase, that is coal bearing, and that is best developed in the southern and western parts of the great area, principally in the Donetz and Toula basins.

## COMPARISON OF GENERAL SECTIONS

Russia	Character of Terranes	Mississippi Valley
Tartaran, Permo-Trias, or Upper Permian, P <sub>3</sub>	Shales and marls, red and variegated, shaly sand- stones; fossils rare; "Red Beds"	Cimarron Series
Middle Permian, P <sub>2</sub>	Limestones, some dolomitic, separated by calcareous marl	(Marion li.) } Series
Lower Permian, P <sub>1</sub> -b	Shales (only 200 feet thick in Kama Valley)	----- ? } Series
Upper Permo-Carbonifer- ous (base of original Permian) CPc.	Limestone, heavy dolomitic	(Chase li.) }
Artinsk, CP.	Shales, sandstones, some thin limestones	(Neosho) (Cottonwood) } (Wabaunsee) } Series
Upper Carboniferous, C <sub>3</sub>	Limestones and shales, highly fossiliferous	Missourian Series
Moscouan, Middle Carbon- iferous, C <sub>2</sub>	Shales, sandstones, thin lime- stones, coal-bearing	Des Moines Series
Lower Carboniferous, C <sub>1</sub>	Limestones chiefly, some shale and sandstone	Mississippian Series

In the consideration of a theme like the present one, it is recognized at the outset, that comparisons of terranes of different geological provinces involves no necessary exact synchrony, except through absolute physical means of correlation. Such a standard, independent of intrinsic features of the terranes themselves, is not yet formulated for widely separated districts. The shortcomings of the common fossil criteria, in any other than the most general way and in the absence of something better, are well known. Any agreement of biotic features in stratigraphic successions distantly removed from one another are looked upon, so far as indicating simultaneous origin, only as happy accidents. Instead of furnishing proofs of time equivalency, it suggests for similar faunas only likeness of conditions, irrespective of time. Such faunal facies are only representative. They are merely homotaxial.

Any similarity of lithological succession is likewise accidental. The same is manifestly true of any other agreement of intrinsic features.

Nevertheless, a comparison of general geological sections in provinces so widely separated as the two under consideration, and so wholly distinct from each other in their origin, can be made not only suggestive but very profitable. The same problems for solution arise in both districts. The naturally different manner of treatment is mutually helpful in the solution of the various difficulties that are presented. Misconceptions regarding each are dispelled. Greater independence in the consideration of succession is established.

The most remarkable fact connected with the Russian section of the Upper Paleozoic and that of Kansas is that the two should be capable of any comparison at all. While the two differ much in stratigraphic, lithological, and biotic details, in general all three classes of characters present a very similar sequence.

*Lithological features.*—In the Russian and American Permian provinces, the field appearance of the rocks is very strikingly alike. This is particularly true of the upper half of the two sections. The general features are lost in the local examinations.

In the Russian district one finds it difficult to imagine that he is not wandering through some part of Kansas. Only the presence of the Russian peasant, or sudden contact with a village of the steppes dispels the illusion. In the Upper Paleozoic the aspects of the limestones and shales, their succession and expression are the same on the banks of the Volga or Kama as they are in the bluffs of the Missouri or Kansas rivers.

The original Permian strata are indistinguishable, lithologically, from the so-called Permian of Kansas. In both there are the same gray and variegated sandy shales and marls, passing locally into sandstones, that are often copper-bearing. Occasionally there are present thin bands and beds of buff earthy limestone. Gypsum is abundantly developed in beds and interspersed everywhere through the rocks. Saline shales are of not infrequent occurrence. On both continents all these pass upward into "Red Beds," that are almost destitute of fossils. Whether the last mentioned strata are Permian or Triassic is still, in both countries, an open question.

*Range of faunas.*—The succession of faunas appears to be essentially the same in the Russian Carboniferous and Permian as in the Mississippi valley. The composition of each of the faunas is also strikingly comparable. The most noteworthy feature of the organic remains, viewed as a whole, is the gradual replacement of a purely marine type by a shore and brackish water phase, as the change from open sea to closed water conditions took place, and finally to those in which life could not exist.

The most prominent characteristic of the biotic change from a Carboniferous phase to a Permian one seems to be the replacement of a predominantly brachiopod fauna by one in which lamellibranchs formed the preponderant element. This change has not, however, the deep significance usually attached to it. There are many other factors that appear to be largely or entirely overlooked. Faunal considerations should dwell more particularly on some of these other features, rather than upon a detailed tabulation of specific sequence.

The chronologic equivalence and comparison of rocks being universally based almost wholly upon the standard of the fossils is at best a very uncertain criterion. In the case of the Permian this uncertainty has been increased tenfold on account of the peculiar treatment that the fossils have received. The investigation of the biotic characteristics of the Upper Paleozoic has been very unsymmetrically developed and very unequally carried out. This is true in both Russia and America. From the published material no comparison of faunas is really possible; that is, in the sense that modern work demands. This chaotic condition of affairs is not anomalous. It occurs with many other faunas from many different horizons. In the present instance it is merely accentuated by a combination of accidental circumstances.

A most noteworthy factor is the extreme local character of the well known, published information. A single American instance suffices for illustration. Our best knowledge of the faunas of the Upper Coal Measures (Missourian) is derived almost entirely from a single horizon, at the single locality of Plattsmouth, Nebraska. This place has been made classic by Geinitz and Meek. All faunal comparisons, made through secondary means, of the rocks of the Mississippi valley above the lower productive Coal Measures (Des Moines) can take into consideration only the little pamphlet of Geinitz and the thin volume of Meek. Much has been made of this horizon by Waagen, Tschernyschew and other foreign paleontologists. Our American workers among the fossils have also depended largely upon the same sources of information.

As a matter of fact, the fauna of the Plattsmouth is characteristic not of a single, insignificant terrane, but of the entire Missourian series, and upward almost to the limits of the fossiliferous zones of the upper Paleozoic of the region—that is to the Marion. To be sure, as to numbers, the various species are differently represented at the several horizons; some forms are not reported yet from this level or that one; others appear that are not recorded from the Plattsmouth beds; yet, for a region in which no effort has ever been made to exploit systematically



the various horizons, and for a great succession of abundantly fossiliferous beds in which our published information is meager in the extreme, it is remarkable through how great a vertical interval the main characteristics of this Plattsmouth fauna are preserved.

The Plattsmouth remains are referred to as forming a characteristic maritime fauna. So it is, but it is identically the same fauna that is found at half a hundred other horizons between the lower coal measures and the "Red Beds." Whenever the heavy limestones occur the same groups of brachiopods appear. Whenever the more argillaceous shales are found the same lamellibranchs begin to predominate. Where the sandstone and coal-bearing shales are prominently developed coal plants and peculiar lamellibranchs and gasteropods are in evidence. These distinct faunas succeed one another in the same vertical section. They are repeated scores of times. Pretty nearly the same phenomena appear to obtain in the great Carboniferous basin of eastern Russia. In both regions the gradual replacement of the brachiopodous fauna by a "Permian" lamellibranch fauna follows the local change of open to closed sea conditions.

The Permian element of these faunas was merely a shallow water facies of the more typical Carboniferous fauna. It oscillated horizontally back and forth with each local change of bathymetric conditions. It was repeatedly intercalated between horizons carrying the greater thalassic phase. Meek's contention for the fauna of the Plattsmouth beds was for its identity with the fauna of the upper coal measures of the region. He was right. In his argument for the Permian character of the same fossils Geinitz was not wholly wrong. The point of vantage of each was merely slightly different. Could they have consulted more fully, they would have been no doubt soon in close agreement.

#### TAXONOMIC RANK OF THE PERMIAN

*Principles of geological classification.*—It is a well-known fact that the modern classifications of animals and plants are based primarily upon genetic relationship. A natural arrangement of

rock terranes is likewise genetic. It is strictly a function of cause and effect. It is only regarding the position of any particular component in a classification, that is subject to a difference of individual judgment. The taxonomic rank of a group may be subject to change as knowledge increases. Among organisms an advancement in rank is frequent. Families eventually attain the rank of orders; genera of families; smaller groups are classed as genera. The same is true of geological formations.

Recognizing, in the taxonomy of rock terranes, the five taxonomic ranks of group or assemblage, system, series, stage, and zone, as amply sufficient subdivisions, at least for all practical purposes, a succession of beds at first given only the rank of a stage may be subsequently advantageously raised to that of series. Stage is a local unit; while series is a provincial one; and system essentially universal.

In applying these principles to the Permian, the question resolves itself into two distinct phases: What should be considered the taxonomic rank of the original Permian? and What is the rank of the succession of beds in this country, referred to the Permian?

*Taxonomic position of the Original Permian.*—Regarding the rank of the so-called Permian in general, there is much difference of opinion. The older school of geologists, that is permeated thoroughly with the idea that fossil faunas are exactly recognizable the world around, and that we can by them and without effort synchronize the provincial rock successions of different continents, is inclined to recognize in the Permian a universal extension, and to assign it a rank of a system, comparable to Carboniferous or Devonian. The more modern school of geological investigators, that tests classification and correlation by more than a single standard and that is seeking exact results and genetic relationships, would consider the original Permian as a provincial succession, and give it the rank of a series, under the more comprehensive system of the Carboniferous.

If one were to attempt anew to classify the upper Paleozoic deposits of eastern Russia, following the criteria that we have adopted in this country, he would have no hesitancy in assigning to the Permian of that region the rank of a series, and make it a subdivision of the Carboniferous. There is, however, a strong possibility of three or more well marked members being recognized in the original Permian succession, the rank of each of which is certainly higher than that of stage. The uppermost, or Tartaran, division is an example. This may prove to be Triassic in age. The inevitable tendency to advance the rank of such divisions, with the progress of knowledge regarding them, makes it almost certain that the divisions mentioned as having the same rank as the Tartaran, will be eventually regarded as series. Permian will then have to be either advanced to the rank of system, or to a new order intermediate between system and series. The latter course is manifestly not only unnecessary, but undesirable, and according to our present principles, unnatural. The former course is of very doubtful utility, and not feasible on account of the almost universal apathy on part of geologists to increase the present number of recognized systems. When the time comes to regard the present divisions of the original Permian as distinct series, Murchison's term will be, in all probability, quietly dropped. It would appear then, that all things considered, the original Permian can be at best only regarded as a series, and a part of the Carboniferous. The term like many others will then only have an historical significance.

*Subdivisions of the so-called Permian beds of the Mississippi valley.*—Most Americans, who are at all familiar with the subject, are inclined to regard the beds referred to the Permian as forming a main division of the Carboniferous. The text-books, as a rule, express this view also, and subdivide the Carboniferous system into three parts, the Sub- or Lower Carboniferous, the Coal Measures, and the Permian. With the recent general adoption of the more systematic method of stratigraphic nomenclature and a tendency to impart technical exactness by the use of geographic names, the first named division in this region has

been called the Mississippian series. In its broadest sense the so-called Lower, or Productive Coal Measures finds satisfactory expression in the Des Moines series. For the "Upper Coal Measures" nearly to the usually selected horizon for the base of the Permo-Carboniferous, Missourian has been suggested as a serial name.

The uppermost division of the Paleozoic of the region, the part widely designated as the "Red Beds," has received the title of Cimarron series. It appears to form a tolerably compact sequence, though there is still some dispute as to its exact geological age. Between the Cimarron series and the Missourian series are two other terranes that are well defined. One is composed of the Chase and Marion of Prosser, in part, and the other of the Wabaunsee, Cottonwood, and Neosho.

Should some such subdivision of the Upper Paleozoic be found applicable over the larger portion of the Mississippi basin, as now seems likely, the use of Permian and Permo-Carboniferous will be rapidly discontinued, or will be invoked only in historical reference.

#### RELATIONS OF "UPPER PERMIAN" TO TRIASSIC

There is little satisfactory data upon which to correlate the beds called Triassic in eastern United States with other regions. The determinations appear to have been largely made upon lithological grounds and plant remains. There is no real physical relation between the Triassic, or Newark in the main, of the Atlantic border, and the Triassic of the region lying to the east of the Rocky Mountains.

The "Red Beds" of Kansas and Texas are thought by some writers to be Triassic in age; by others Permian. In the almost total absence of fossils in these beds, the lithological characters and general red coloration have been resorted to as criteria. Of late the question has been taken up anew. Prosser has been led to believe that the greater part of the Kansas "Red Beds" are Triassic. Williston, from even more reliable data, is inclined to regard the lower part at least as Paleozoic.

The question bids fair to remain unsettled, until some data more tangible and critical are obtained. The deposits of the Triassic of this region were laid down nearly under the same conditions as some of the so-called Permian. The beds appear to have been formed without interruption of sedimentation in enclosed basins. Vertebrate and plant remains are to be expected to form the prevailing forms of life. They cannot be very well compared with marine invertebrate faunas. Such a comparison would, if attempted, prove unprofitable. The clue must be evidently sought in physical criteria, and in the stratigraphy of the region. Sufficient work in this direction has not been done. The exact line of demarcation between the two must therefore remain undetermined for the present.

While this question is brought up at this time with the full knowledge that it has little bearing upon the main theme here presented, it is alluded to for the express reason that the same problem that has come up in connection with the deposits with which we have been comparing the American so-called Permian, has troubled the Russian geologists in their study of the original Permian area. Their Tartaran "Red Beds" are as perplexing as ours; and the opinions as to age are equally divided. Several writers, notably Karpinsky, Nikitin, and Tschernyschew are of the opinion that these deposits were laid down in isolated inclosed brackish water lakes, that continued to exist into the Triassic period. On the other hand, another group of equally shrewd observers, headed by Amalitzky, Schtukenberg, Netchaiev, and Krotov, regard all of these beds as Paleozoic. For all practical purposes the views of the last mentioned workers appear most reasonable.

In this country, the conditions appear identical with the Russian. Amalitzky's idea is equally applicable here, unless it is shown that marked and widespread unconformities exist near or at the top of the American "Red Beds" and that the undoubted Triassic can be thus clearly separated.

RECAPITULATION

Returning to the original questions, propounded at the beginning, all available evidence appears to indicate :

1. That while we have in America a great succession of deposits identical in all essential respects to the original Permian of Russia, the two great basins merely had similar histories that are not necessarily connected, and doubtless were wholly independent of each other and unrelated ; that the Russian Permian constitutes a geological province by itself ; and that therefore the term Permian should not be used as a technically exact term in connection with the Mississippi valley deposits.

2. That Permian, as originally proposed, applies to a provincial series, and according to our usual standard has at best a taxonomic rank below that of system. Also, in view of the possible elevation of its main subdivisions to the rank of series, the term will have no position in the general scheme of classification. It will be no doubt eventually dropped altogether. The various series belonging to the succession and now having lower rank, will be considered main subdivisions of the Carboniferous system. In this country the same plan has been already proposed.

3. That, with the solution given to the second question, it is unnecessary to attempt to locate the limits of the so-called Permian in this country. The divisional lines of the series comprised in the typical American section in Kansas are already well defined, with the possible exception of that of the uppermost member.

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